Knowledge-based Capital and Growth: What do we Know and What do we Need to Know?

Slides for session of same title in conference:

GROWTH, INNOVATION AND COMPETITIVENESS - MAXIMISING THE BENEFITS OF KNOWLEDGE-BASED CAPITAL

13-14 February 2013, Paris

Link to conference homepage

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Papers and cross-country data at www.intan-invest.net

Motivation

"We will be more likely to promote innovative activity if we are able to measure it more effectively and document its role in economic growth"

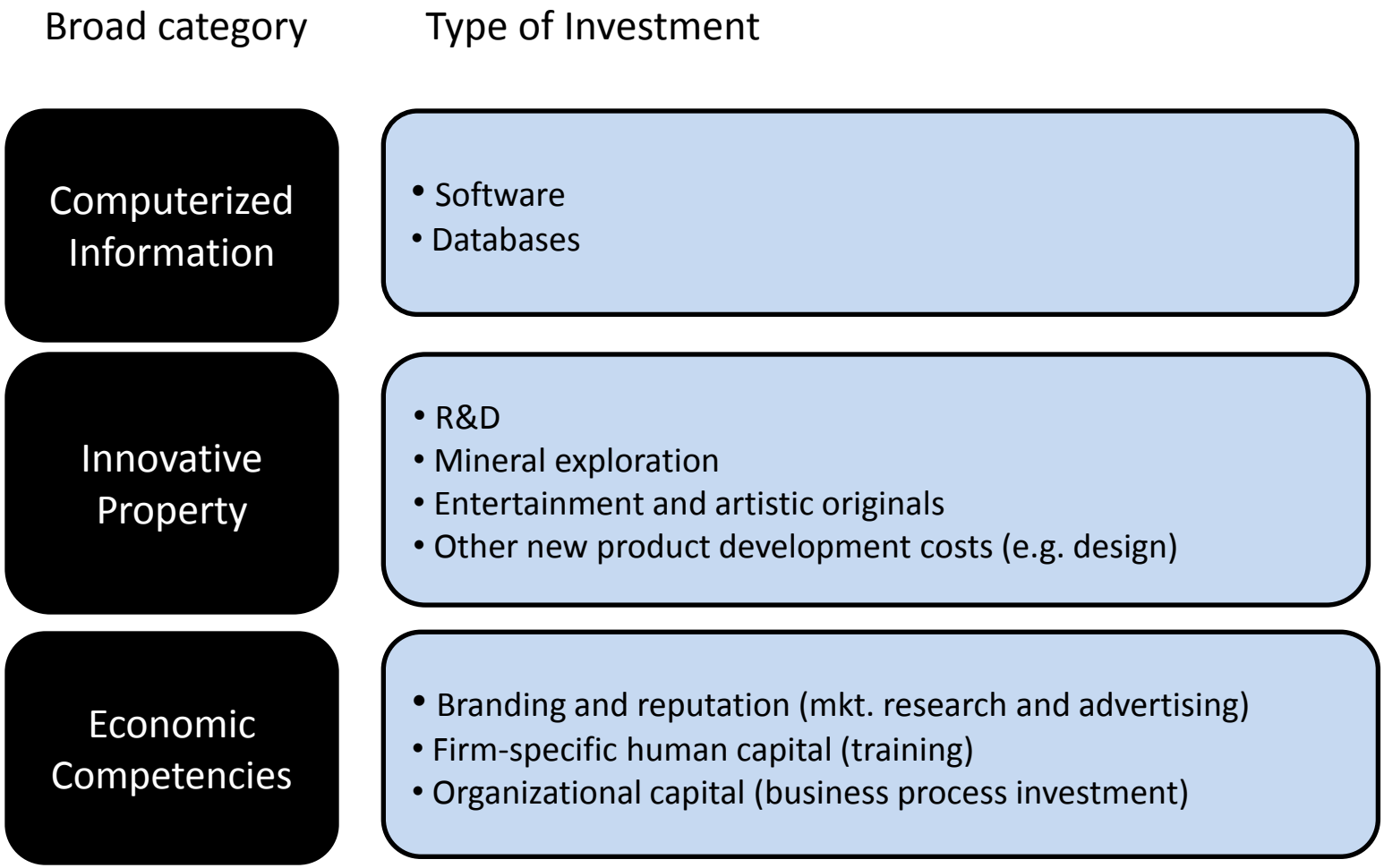
Ben Bernanke, May 2011, Speech in Washington DC at Athena Alliance/OECD Conference

Our mission: to better understand economies….

Which used to produce this…..

..and now produce this.

The CHS framework



Source: Corrado, Hulten and Sichel, 2005, 2009 and Carol Corrado, OECD/MIT presentation, NAS, December, 2012

Intangible investment matters

1. New investment N creates stock R => new GDP

$$P^Q Q = P^C C + \underbrace{P^I I + P^N N}_{\text{Total investment}} = P^L L + \underbrace{P^K K + P^R R}_{\text{Total capital payments}}$$

$$d \ln Q = s_Q^C d \ln C + s_Q^I d \ln I + \underbrace{s_Q^N d \ln N}_{\text{Addition to GDP growth}}$$

2. TFP with and without intangibles

$$Q = AF(L, K, R)$$

$$d \ln TFP = \underbrace{d \ln Q}_{\text{Different output}} - (s_Q{}^L d \ln L + s_Q{}^K d \ln K + \underbrace{s_Q^R d \ln R}_{\text{More input}})$$

compare

$$V = A^- F(L, K)$$

$$d \ln TFP^- = d \ln Q^- - (s_Q^{-L} d \ln L + s_Q^{-K} d \ln K)$$

Model drives research questions

- See discussion of all these points in Corrado, Haskel, Jona-Lasinio Iommi(2012) at www.intan-invest.net
- Measurement
  - Relation with alternative measurement e.g. innovation surveys
  - Difficult measurement issues
    - List of assets
    - Investment
    - Prices of intangible assets
    - Depreciation
    - Mark-ups
- Conceptual objections
  - "Intangible spending is not investment since it does not last"
  - "Investment in intangibles is ultimately people. So it's all double counting with human capital"
  - "Ideas don't depreciate"
- What facts and policy implications (if any) have we uncovered?
  - Facts: Have we missed a lot or a little output and investment? Has TFP changed? Do we have the right statistical systems to measure it with confidence?
  - Policies: Are there intangible spillovers? Can policy help?

Prices of intangibles: are intangibles *more* important than we think?

$$\Delta \ln P^N = s_N^K \Delta \ln P^K + s_N^L \Delta \ln P^L - \Delta \ln TFP^N$$

- Current methods for $\Delta \ln P^N$
  - for R&D capitalization :
    - share-weighted input costs (UK: 1985-05 = 4%pa)
    - no (EU) or some (USA) adjustment for $\Delta \ln TFP^N$
  - For intangibles:
    - GDP deflator (3.5%pa)
- If fast TFP growth in innovation sector, this might *understate* importance of intangibles since capital stocks are higher than measured
  - $\Delta \ln TFP^N$ might be fast
    - the internet/information technology in science
    - Formation of teams of scientits
  - Many innovative goods seem to have strong price declines
    - Hardware (-17% pa), Coms equip -4%pa, pre-packaged software (falls around 4.5%pa)
- Example of difference:
  - Contrib of R&D to UK GDP growth, 1995-05, input costs = 0.03%pa
  - Contribution using Corrado, Goodridge, Haskel 0.25%pa
  - Suggests productivity adjustment matters a great deal

Spillovers

Production function

$$\Delta \ln Q_{c,i,t} = \varepsilon^{L}_{c,i,t} \Delta \ln L_{c,i,t} + \varepsilon^{K}_{c,i,t} \Delta \ln K_{c,i,t} + \varepsilon^{R}_{c,i,t} \Delta \ln R_{c,i,t} + \Delta \ln A_{c,i,t}$$

First order condition

$$\varepsilon^{X}{}_{c,i,t} = s^{X}{}_{c,i,t} + d^{X}{}_{c,i,t} \quad , X = L, K, R$$

Definition of TFP

$$\Delta \ln TFP_{c,i,t} = s^{L}_{c,i,t} \Delta \ln L_{c,i,t} + s^{K}_{c,i,t} \Delta \ln K_{c,i,t} + s^{R}_{c,i,t} \Delta \ln R_{c,i,t}$$

=>

Regression approach 1

$$\Delta \ln Q_{c,i,t} = (s^{L}_{c,i,t} + d^{L}_{c,i,t}) \Delta \ln L_{c,i,t} + (s^{K}_{c,i,t} + d^{K}_{c,i,t}) \Delta \ln K_{c,i,t} + (s^{R}_{c,i,t} + d^{R}_{c,i,t}) \Delta \ln R_{c,i,t} + \Delta \ln A_{c,i,t}$$

Regression approach 2

$$\Delta \ln TFP_{c,i,t} = d^{L}_{c,i,t} \Delta \ln L_{c,i,t} + d^{K}_{c,i,t} \Delta \ln K_{c,i,t} + d^{R}_{c,i,t} \Delta \ln R_{c,i,t} + \Delta \ln A_{c,i,t}$$

Compare with:

$$\Delta \ln Q_{c,i,t} = (1 - s^{R}_{c,i,t}) \Delta \ln V_{c,i,t} + s^{R}_{c,i,t} \Delta \ln N_{c,i,t}$$

$$= (s^{L}_{c,i,t} + d^{L}_{c,i,t}) \Delta \ln L_{c,i,t} + (s^{K}_{c,i,t} + d^{K}_{c,i,t}) \Delta \ln K_{c,i,t} + (s^{R}_{c,i,t} + d^{R}_{c,i,t}) \Delta \ln R_{c,i,t} + \Delta \ln A_{c,i,t}$$

Spillovers

- Data
  - Intangible assets: INTAN-Invest Database (Corrado, Haskel, Jona-Lasinio, Iommi (2012)), www.intan-invest.net
- Production function variables
  - EUKLEMS, OECD STAN and WIOD Databases
- Country/time/industry:
  - AT, DK, FI, FR, GE, IT, NL, SP, SWE, UK, US
  - Yearly data: 1995 - 2007
  - Industries: 26 (NACE Rev. 2 Classication)
  - 11 countries, 1995-2007

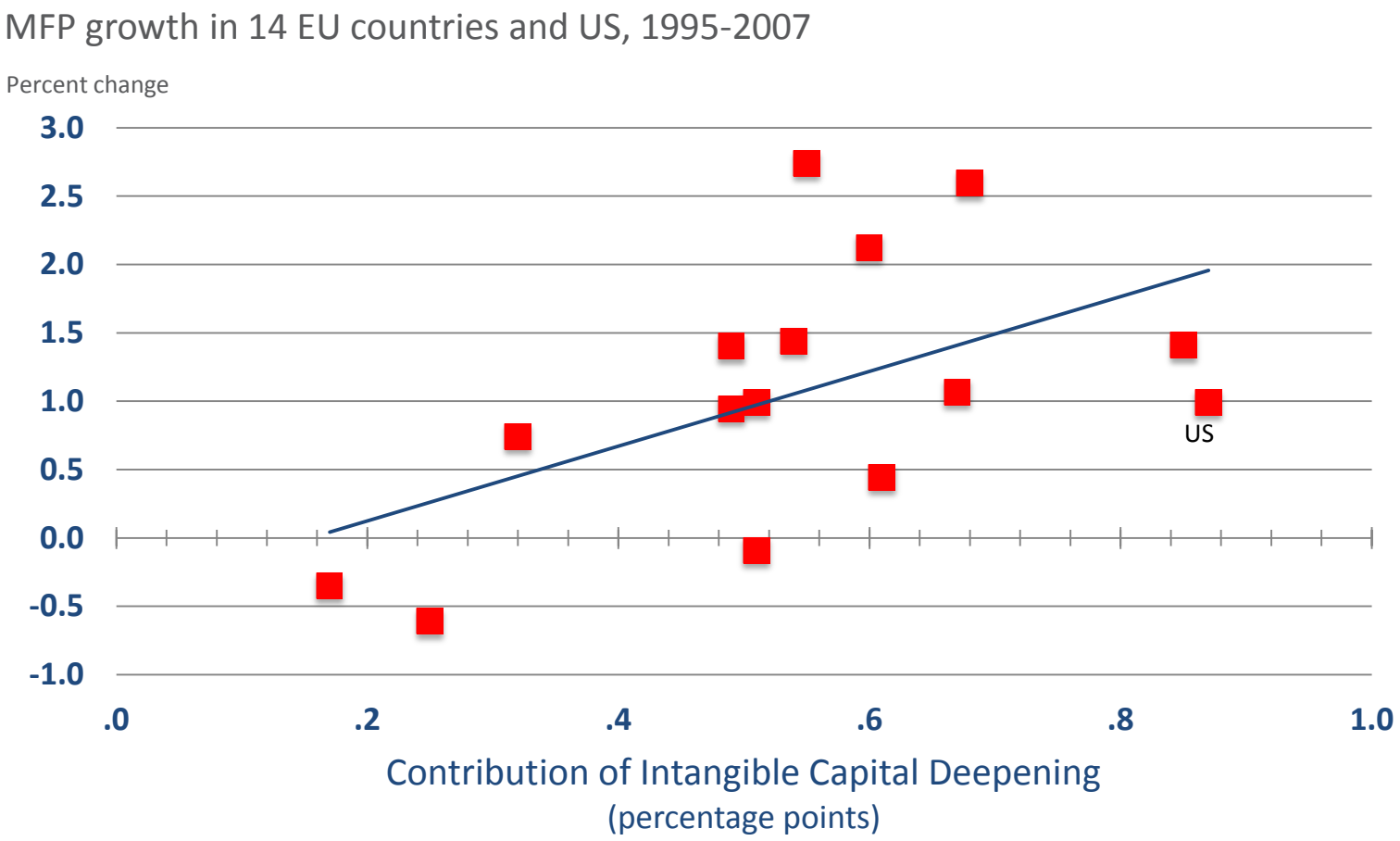
Regression 1

$$\Delta \ln(Q/L)_{c,t} = \alpha_1 \Delta \ln\left(K_{c,t}^{ICT} / L_{c,t}\right) + \alpha_2 \Delta \ln\left(K_{c,t}^{NonICT} / L_{c,t}\right) + \alpha_3 \Delta \ln\left(R_{c,t} / L_{c,t}\right) + \alpha_4 \Delta \ln L_{c,t}$$
$$+ \lambda_c + \lambda_t + \nu_{c,t}$$

Regression 2

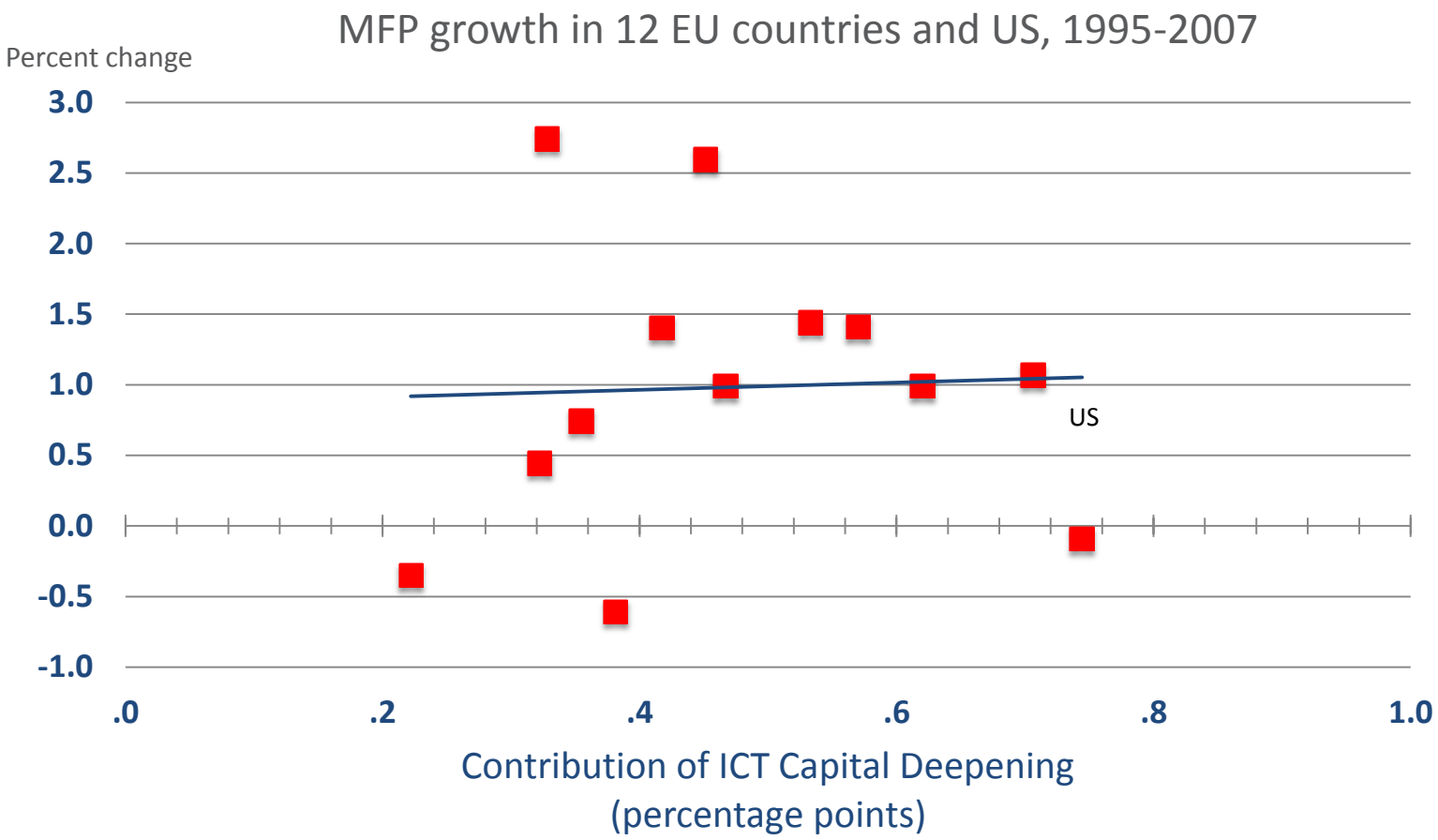
$$\Delta \ln TFP_{c,t} = \beta_1 \Delta \ln\left(K_{c,t}^{ICT} / L_{c,t}\right) + \beta_2 \Delta \ln\left(K_{c,t}^{NonICT} / L_{c,t}\right) + \beta_3 \Delta \ln\left(R_{c,t} / L_{c,t}\right) + \beta_4 \Delta \ln L_{c,t}$$
$$+ \lambda_c + \lambda_t + \nu_{c,t}$$

Basic relation MFP and intangibles: spurious correlation or spillovers?



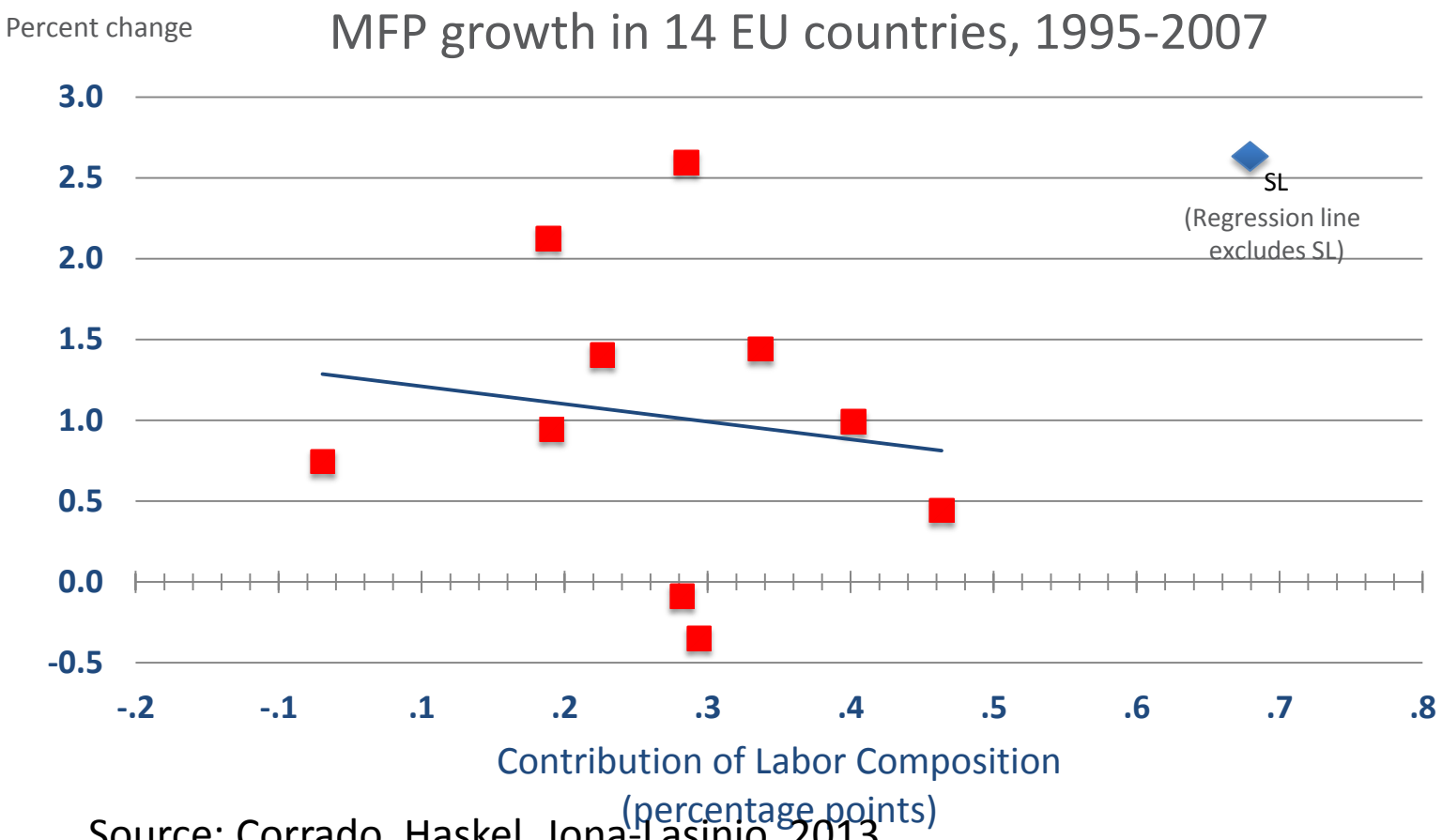
Source: Corrado, Haskel, Jona-Lasinio, 2013

No hint of spillovers to ICT capital deepening



Source: Corrado, Haskel, Jona-Lasinio, 2013

… nor for labor composition ("quality").



Source: Corrado, Haskel, Jona-Lasinio, 2013

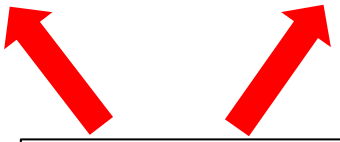
Do intangibles boost TFP growth?
(dependent variable: ΔlnTFP country/time)

	1	2	3	4	5	6	7	8
Intang adjusted?	Unadjusted	Unadjusted	Adjusted	Adjusted	Unadjusted	Unadjusted	Adjusted	Adjusted
Estim method	OLS	OLS	OLS	OLS	IV	IV	IV	IV
VARIABLES:								
Dln(R/L)			0.155	0.249**			0.0508	0.137*
(share=0.10)			(0.131)	(0.119)			(0.0905)	(0.0792)
Dln(K/L)ICT	-0.258***	-0.200***	0.0260	0.0779	-0.163***	-0.156**	0.0200	0.0259
(share=0.05)	(0.0382)	(0.0495)	(0.0545)	(0.0580)	(0.0369)	(0.0661)	(0.0503)	(0.0485)
Dln(K/L)NonICT	-0.467***	0.347***	-0.00819	0.0449	-0.146***	-0.177**	-0.0156	0.0135
(share=0.26)	(0.0792)	(0.0906)	(0.113)	(0.111)	(0.0476)	(0.0783)	(0.0594)	(0.0565)
DlnL	-1.259***		-0.418**		-1.258***		-0.141	
	(0.129)		(0.204)		(0.0879)		(0.130)	
DlnL(t-1)		-0.0383		0.636***		-0.909***		0.267**
		(0.147)		(0.167)		(0.128)		(0.120)
Observations	108	99	108	99	99	99	99	99
R-squared	0.861	0.778	0.547	0.557	0.726	0.500	0.428	0.485

Complementarities

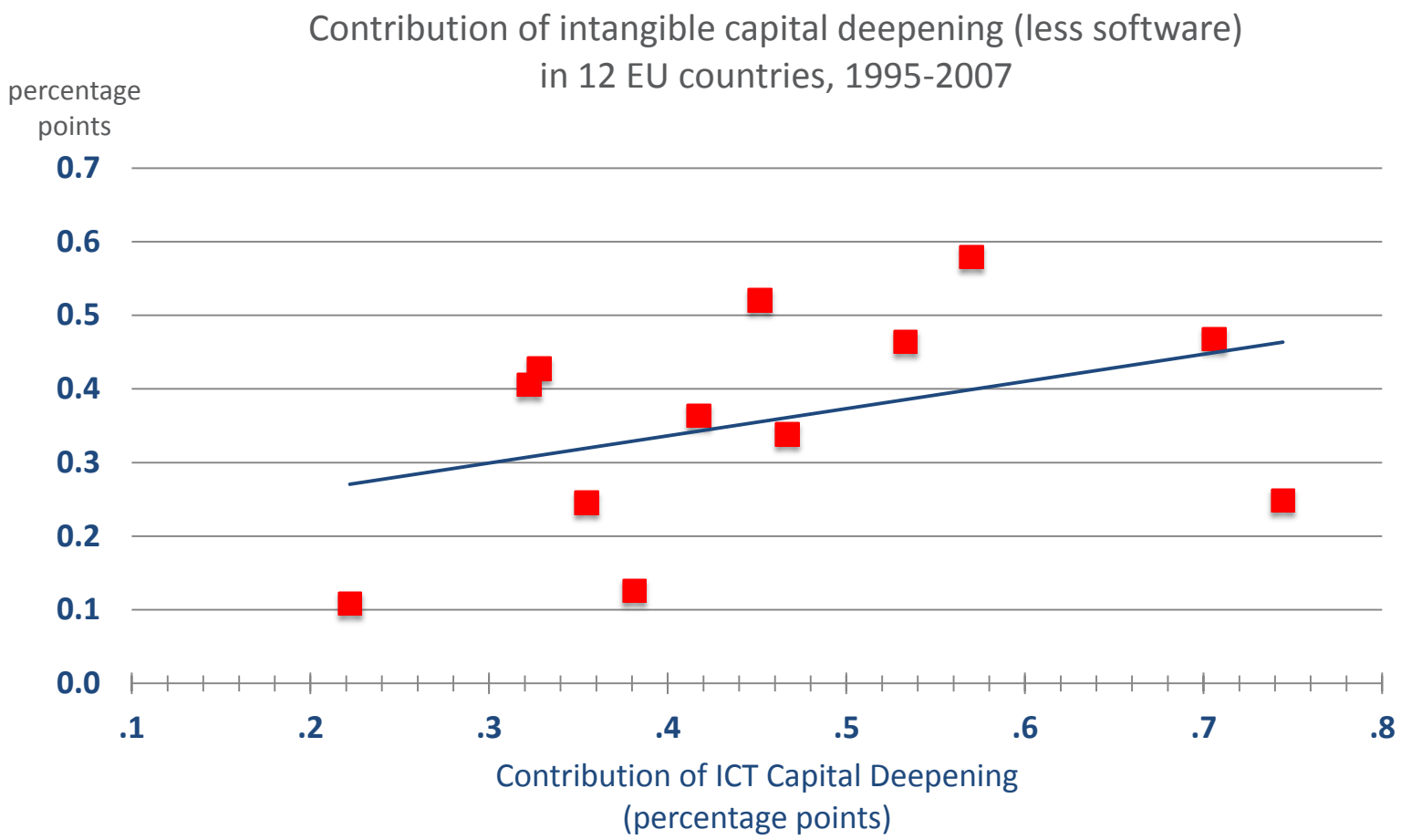
- 11 countries, 26 industries, 1995-2007

$$\Delta \ln(V/L)_{i,c,t} = \gamma_1 \Delta \ln\left(K^{ICT}_{i,c,t} / L_{i,c,t}\right) + \gamma_2 \Delta \ln\left(K^{NonICT}_{i,c,t} / L_{i,c,t}\right) + \gamma_3 \Delta \ln\left(R_{i,c,t} / L_{i,c,t}\right)$$
$$+ \gamma_4 \Delta \ln\left(R_{i,c,t} / L_{i,c,t}\right) \times \overline{\left(K^{ICT}_{i,c,t} / L_{i,c,t}\right)} + \gamma_5 \overline{\left(K^{ICT}_{i,c,t} / L_{i,c,t}\right)} + \lambda_i + \lambda_c + \lambda_t + \nu_{i,c,t}$$



In country c,
Or in USA

Intangible assets and ICT capital deepening are correlated



Source: Corrado, Haskel, Jona-Lasinio, 2013

Are ICT and intangibles complements?

$$\Delta \ln(V/L)_{i,c,t} = \gamma_1 \Delta \ln\left(K^{ICT}_{i,c,t}/L_{i,c,t}\right) + \gamma_2 \Delta \ln\left(K^{NonICT}_{i,c,t}/L_{i,c,t}\right) + \gamma_3 \Delta \ln\left(R_{i,c,t}/L_{i,c,t}\right)$$
$$+\gamma_4 \Delta \ln\left(R_{i,c,t}/L_{i,c,t}\right) \times \overline{\left(K^{ICT}_{i,c,t}/L_{i,c,t}\right)} + \gamma_5 \overline{\left(K^{ICT}_{i,c,t}/L_{i,c,t}\right)} + \lambda_i + \lambda_c + \lambda_t + \nu_{i,c,t}$$

	ICT-C		ICT-US	
VARIABLES	**OLS**	**IV**	**OLS**	**IV**
[DNICT]	0.0803***	0.104**	0.0789***	0.126**
	(0.0240)	(0.0518)	(0.0241)	(0.0509)
[DICT]	0.0236**	-0.0268	0.0248**	-0.00500
	(0.0116)	(0.0258)	(0.0117)	(0.0248)
[DTOTINTG]	0.636***	0.699***	0.434***	0.398***
	(0.0456)	(0.0916)	(0.0338)	(0.0509)
[ICT-INTENSITY]	0.123***	0.101*		
	(0.0253)	(0.0518)		
[ICTXDTOTINTG]	**0.108*** **	**0.145*** **		
	(0.0263)	**(0.0451)**		
[ICT-INTENSITY-US]			0.115***	0.108***
			(0.0272)	(0.0258)
[ICT USXDTOTINTG]			**0.0938*** **	**0.136*** **
			(0.0282)	**(0.0431)**
Observations	2,268	2,079	2,268	2,079
R-squared	0.390	0.291	0.388	0.293

Summary: intangibles are more important than you think

- Most are omitted from investment
  - Conventional national accounts does not measure them at all (with some exceptions)
- Deflators
  - Experimental work deflates nominal spend with the GDP deflator or cost inflation. But if there are technology improvements in intangible production (the internet, open source software) the *true* deflator rises more slowly/falls. Thus real intangibles are growing faster than we think.
- Spillovers
  - Intangibles raise productivity of the firm that invests in them. But they might also raise productivity for other firms who use that knowledge.